ELECTRODE KINETIC BEHAVIOR OF METALLIC SURFACES

Final Technical Report

Office of Naval Research

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This research program was concerned primarily with the study of the influence of metallic structure and composition on the electrode kinetic and corrosion behavior of metal surfaces. Office of Naval Research support for the program covered the period of September 1, 1962 through August 31, 1966.

Since the complete details of research progress have been given in five technical reports and a patent application, only the most pertinent results are summarized briefly below.

Technical Report #1 - Electrode Mounting for Potentiostatic Anodic Polarization Studies May, 1965

The results of this study show that even microscopic crevices at an electrode mount interface can produce pronounced error in passive current measurements during potentiostatic anodic polarization experiments. The importance of avoiding all crevices when mounting electrodes for electrochemical studies was not recognized generally prior to this study.

Technical Report #2 - Principles of Metallographic Etching - June, 1965

The field of metallographic etching has been

traditionally more an art than a science. The purpose of this study was to determine the controlling parameters in the metallographic etching of multiphase alloys and provide a more scientific basis for the development of new etches.

Tin-zinc alloys in sodium hydroxide solutions were chosen as the most suitable system for study. Etching rate and contrast were found to be unique functions of electrode potential. Identical etching results were obtained by potentiostatic, electrolytic, and chemical techniques when performed at the same electrode potential. In addition, it was found that to produce sufficient metallographic contrast, the dissolution rate of a given phase must be at least 5 times greater than the surrounding matrix unless a colored insoluble dissolution product is produced.

The results show that new metallographic etches can be designed on a scientific rather than an empirical basis.

Technical Report #3 - Predicting the Intergranular Corrosion of Austenitic Stainless Steels
October, 1965

A continuous grain boundary precipitate of chromium-

rich carbide is known to be a necessary but not sufficient cause for the intergranular corrosion of austenitic stainless steels. Since intergranular attack does not occur in many environments, expensive preventive measures can often be avoided. The purpose of this investigation was to determine the precise environmental conditions under which these steels corrode intergranularly.

The results provide a method for rapidly predicting the intergranular susceptibility of various sulfuric acid-oxidized mixtures on the basis of corrosion potential measurements and controlled potential corrosion tests.

Technical Report #4 - Passivation of Crevices during Anodic Protection - February, 1968

The ability to passivate narrow crevices is an important factor in practical applications of anodic protection. The work described in Technical Report #1 was extended to investigate the factors controlling the passivation of crevices.

Theoretical analyses and experimental studies with a special crevice assembly demonstrate that the most important parameter is the critical anodic current

density; i.e., of the protected metal. Thus selecting alloys for anodic protection applications with small critical anodic current densities reduces the current requirements for initial passivation and improves the crevice-passivating ability of the system.

Technical Report #5 - The Variable Corrosion Resistance of 18 Cr - 8 Ni Stainless Steel, to be issued March, 1968

It is well known that similar heats of 18 Cr - 8 Ni can vary by as much as fifty-fold in their corrosion resistances.

Using electrochemical techniques, conventional corrosion testing, and multiple correlation analyses, the corrosion behavior of a large number of commercial heats of Types 304 and 316 stainless steel was examined in detail. It was found that the differences in behavior among the heats was due almost entirely to slight variations in chemical composition.

The following equation was developed which describes the effect of various elements on the critical anodic current density, i_c. Corrosion resistance is inversely proportional to critical anodic current density.

$$I_c = 15471 + 373\ (Mn) + 7600\ (S) - 750\ (Mo)$$
$$-6500\ (C) - 840\ (Cr) - 1240\ (Cu)$$

where I_c = microamperes/cm^2 and alloy composition is in weight per cent.

On the basis of this study a patent application, "Stainless Steel Compositions with Increased Corrosion Resistance", was filed 31 October, 1966. The application bears Serial No. 591,352, and is further identified as Navy Case No. 41,478.

During the course of this program, two Ph. D. candidates, B. E. Wilde and W. D. France, Jr., were completely supported in their doctoral research. In addition, the research of several Masters' candidates, including France, was either completely or partially supported.

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13. ABSTRACT

The primary purpose of this program was to relate the electrode kinetic and corrosion behavior of metallic surfaces to metallographic structure and function.

Since complete research details have previously been presented in five technical reports, and a patent application, only the most important results are briefly summarized in this final report.

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